

Application Serial No: 11/040,297
In reply to Office Action of 24 June 2005

Attorney Docket No. 83303

REMARKS / ARGUMENTS

First, the Applicant appreciates the courtesies extended by the Examiner during the telephonic interview conducted on September 7, 2005. The remarks that follow reflect the conversations of the interview and the respective summary of September 12, 2005.

Claims 1-13 are currently pending in the application and rejected to. Claims 3, 4, 10 and 11 have been cancelled without prejudice or disclaimer and claims 1, 5, 7, 8 and 13 have been amended by this response.

According to the Office Action, the limitation of parent **Claim 1** is present invention relates to an electrostrictive terpolymer comprising (A) **vinylidene fluoride**; (B) **trifluoroethylene**; and (C) at least one monomer, wherein said at least one monomer is **an ethylene-based monomer and has at least one halogen atom side group**, wherein said at least one monomer favors **gauche-type** linkage along a backbone of a polymer chain of said terpolymer.

According to the Office Action, parent **Claim 7** relates to terpolymer of Claim 1 with a specific combination of VDF, TrFE, and CFE (chlorofluoroethylene). Parent **Claims 8 and 13** each relates to a method of making film of terpolymer from Claims 1 and 7. See other limitations of dependent **Claims 2-6 and 9-12**.

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The Office Action has rejected claims 1-13 under 35 U.S.C. § 102(b) as being anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over Honn et al (reference A: U.S. Patent No. 3,318,854).

Regarding the limitation of parent **Claim 1**, the Office Action states that **Honn et al.** discloses preparation of various fluorinated elastomeric copolymers comprising repeating units of vinylidene fluoride (VDF), trifluoroethylene (TrFE) and 1-chloro-1-fluoro-ethylene (CFE) as long as at least one of the mono-olefinic compounds must contain at least one carbon atom linked only to hydrogen and carbon atoms (column 2, line 9-41 and 42-66; column 1, line 69-72 and 63-64). Although only dipolymers are exemplified on column 2 at lines 50-66, the terpolymer of VDF-TrFE-CFE) as disclosed in present application would be one among many copolymers therefrom. In a close examination, inherent property to carry the same or similar gauche-type linkage along backbone of polymer chain is thereby existed.

Regarding **Claims 2-6**, the Office Action further states that **Honn et al.** discloses that any ratio on monomers of VDF, TrFE and CFE can be prepared with a condition as **at least 10 percent** of polymer is comprised of **-CH₂-** groups in order to obtain an elastomeric product (column 1, line 63-64; column 2, line 1-8).

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Parent **Claim 7** only relates to a terpolymer of Claim 1 with specific combination of VDF, TrFE, and CFE(chlorofluoroethylene), it can be thereby rejected as above.

Parent **Claims 8 and 13** each relate to a method of making film of terpolymer from Claims 1 and 7. The disclosure on making film, coating and impregnate by Honn et al. on column 5 at lines 5-10 and 65-66 would anticipate the limitations of Claims 8 and 13.

Remaining dependent **Claims 9-12** are thereby rejected with the above rejection for Claims 1-8 and 13.

In the Office Action, claims 1-3, 6, 8-9 and 12 are rejected under 35 U.S.C. § 102(b) as being anticipated by Nakamura et al. (reference B: U.S. Patent No. 4,543,293).

Regarding the limitation of parent **Claim 1**, the Office Action states that **Nakamura et al.** disclose preparation of a fluorinated piezoelectric copolymers comprising repeating units of vinylidene fluoride (VDF) (40-87 mol%); trifluoroethylene (TrFE) (10-40 mol%) and vinylfluoride (3-20 mol %) (abstract, line 1-4; column 2, line 30-36). A small amount of one or more than one fluorinated monomer such as TFE, HFP, chlorotrifluoroethylene (CTFE) may be added (column 2, lines 39-43). It is noted that both vinyl fluoride and CTFE are related to "an ethylene-based monomer and has at least one halogen atom side group". In a close examination on terpolymer's

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composition, inherent property to carry the same or similar gauche-type linkage along backbone of polymer chain is thereby existed.

Regarding Claims 2-3, the Office Action states that Nakamura discloses that both vinyl fluoride and CTFE can be included.

The Office Action further states that parent **Claim 8** relates to a method of making film of terpolymers from Claim 1. The disclosure on making a cast film by Nakamura on column 4 at lines 39-43 and column 6 at lines 3-7 would anticipate the limitation of Claim 8.

Remaining dependent **Claims 6, 9 and 12** are thereby rejected with the above rejection for Claims 1-3 and 8.

The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. § 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

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In the Office Action, claims 4-5, 7, 10-11 and 13 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Nakamura et al. in view of Honn et al.

The above discussion of the disclosures of the prior art of Nakamura of this office action is incorporated here by reference. The above discussion of the disclosures of the prior art of Honn et al. of the Office Action is also incorporated here by reference. Regarding **Claims 4-5, 7, 10-11 and 13**, **Nakamura is only using vinyl fluoride**. Therefore, he is silent about including the monomer of chlorofluoroethylene with additional chlorine atom as compared with vinyl fluoride to be with monomers of VDF and TrFE in the terpolymer. **Honn et al.** teach that a terpolymer comprising repeating units of **vinylidene fluoride (VDF), trifluoroethylene (TrFE) and 1-chloro-1-fluoroethylene (CFE)** can be readily prepared with the condition as "at least one of the mono-olefinic compounds must contain at least one carbon atom linked only to hydrogen and carbon atoms" (column 2, lines 9-41 and 42-66; column 1, lines 69-72 and 63-64). By doing so, when the polymer is combined with different crosslinking agents, a soft or hard vulcanizate as desired can be controllably obtained (column 3, lines 25-43).

In light of the fact that copolymer produced by all the involved references are containing **the same or similar type of**

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fluorinated comonomers as well as both copolymers fit into the guideline as "at least one of the mono-olefinic compounds must contain at least one carbon atom linked only to the hydrogen and carbon atoms", one having ordinary skill in the art would therefore have found it obvious to **modify Nakamura's copolymerization process by replacing vinyl fluoride with 1-chloro-1-fluoro-ethylene** as taught by Honn et al. By doing so, one would expect all embodiments in the same genus would succeed based on functional equivalence and interchangeability. Additionally, one advantage is to obtain a soft or hard vulcanized product with controllable properties as desired when cured with crosslinking agent due to the existence of chlorine atoms.

In the conclusion the prior art made of record and not relied upon is considered pertinent to applicants' disclosure. The following reference relate to an electrostrictive terpolymer comprising **vinylidene fluoride, trifluoroethylene and chlorofluoroethylene**: US Patent No. 4,863,648 to **Scheinbeim et al.** discloses a process for making polarized material by forming a solution of a material capable of being polarized with a polarization solvent with can be removed by evaporation, wherein said material can be copolymers of vinylidene fluoride with vinyl fluoride, TrFE, TFE, vinyl chloride and the like (column 4, lines 55-61; abstract, line 1-4). Chlorofluoroethylene (CFE)

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is not disclosed or suggested as c-monomer at all.

Additionally, gauche-type linkage along backbone of polymer chain is also not disclosed. Therefore, Scheinbeim fails to teach or fairly suggest the copolymers of present invention.

These rejections and objections are respectfully traversed in view of these amendments and remarks that follow:

In the Office Action, claims 1-13 were rejected under 35 USC 102(b) as being anticipated by or, in the alternative, under 35 USC 103(a) as obvious over Hone et.al (U.S. Patent No. 3,318,854). In response, claims 3, 4, 10 and 11 have been cancelled without prejudice or disclaimer and claims 1, 5, 7, 8 and 13 have been amended by this response. More specifically and in accordance with the interview of September 7, 2005 and the respective interview summary, amended claim 1 narrows the language of the claims from "comprising" to "consisting of" and further defines the definition of the monomer of the electrostrictive polymer. As such, the terpolymer of amended claim 1 and dependant claims 2, 5 and 6 is neither taught nor suggested by the Honn reference nor would the terpolymer be obvious in regard to the cited reference. As a result, the rejections of the Office Action are resolved for claims 1 and dependant claims 2, 5 and 6.

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In regard to claim 7, the language of the claim has been amended to "consisting of" to "comprising" to remove the open language defining the electrostrictive polymer. As such, the terpolymer of amended claim 7 is neither taught nor suggested by the Honn reference nor would the terpolymer be obvious in regard to the cited reference. As a result, the rejections of the Office Action is resolved for claim 7.

In regard to claim 8 and dependant claims 9 and 12, the language of claim 8 has been amended to reflect the conclusions discussed in the interview of September 7, 2005. More specifically, amended claim 8 further defines the definition of the monomer of the electrostrictive polymer. As such, the method of amended claim 8 and dependant claims 9 and 12 is neither taught nor suggested by the Honn reference nor would the terpolymer be obvious in regard to the cited reference. As a result, the rejections of the Office Action are resolved for claims 8 and dependant claims 9 and 12.

In regard to claim 13, the language of the claim has been amended to "consisting of" to "comprising" to remove the open language defining the method of synthesizing an electrostrictive polymer. As such, the method of amended claim 13 is neither taught nor suggested by the Honn reference nor would the terpolymer be obvious in regard to the cited reference. As a

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result, the rejections of the Office Action are resolved for claim 13.

To supplement the remarks for claims 1-13 and to further explain the position of the Applicant during the interview of September 7, 2005; it is respectfully requested that the discussion as follows be considered:

In regard to Honn, et al. (U.S. Patent 3,318,854), the cited reference is essentially a synthetic reference describing how to make certain types of polymers. The Honn reference does not go into much detail as to why one skilled in the art would want to do this, or what the end uses of the polymers actually are. The disclosure of the reference actually predates the discovery of piezoelectric behavior in fluorinated hydrocarbon polymers such as PVDF and PVDF-TrFE.

In contrast, the main teaching of the present application describes how to make high strain electrostrictive fluoropolymers solely by chemical techniques. This teaching is not a part of the Honn reference because there was no awareness of such properties in the polymers described in the reference. The goal of the Honn reference was to make "soft", thermoset vulcanizates of fluorinated, linear and saturated elastomers.

Also noteworthy is that the synthetic technique being taught by the cited reference is that of crosslinking fluorinated, linear, saturated polymers so that the polymers

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remain elastomeric. The Honn reference does not claim to have invented the polymers mentioned; what the reference claims are techniques for crosslinking and vulcanizing the polymers. Crosslinking is not a part of the present application.

In the present application, the polymers remain saturated, linear, and uncrosslinked. Crosslinked polymers tend to lose their thermoplasticity and solubility - and both of those characteristics are important for the polymers described in the present application. As such the major purpose of the Honn reference is not relevant to the present application.

The issue raised by the Office Action, namely "at least 10% of the polymers should be $-CH_2-$ units," does not pertain to the present application. The Honn reference states that the reason for this is that the resulting polymers remain elastomeric. The chemistries specified in the present application are necessary to ensure that the resulting polymers exhibit high strain electrostriction. Thus, even though some of the chemical structures may be similar, the reasons why are completely different. The Honn reference did not invent the polymers in that the reference uses known structures (or the structures would be obvious to someone skilled in the field - there are only so many building blocks to link up to make polymers).

As such, the Honn reference has minimal relation with the present application. The only link between the reference and

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the present application is that the chemistries of the polymers used are similar but not identical. The reasons for making these polymers and their properties are completely different, and the Honn reference would not anticipate the end use of the present application.

In the Office Action, claims 1-3, 6, 8-9 and 12 are rejected under 35 U.S.C. § 102(b) as being anticipated by Nakamura et al. (reference B: U.S. Patent No. 4,543,293). In response, claim 3 has been cancelled without prejudice or disclaimer and claims 1 and 8 have been amended by this response. More specifically and in accordance with the interview of September 7, 2005 and the respective interview summary, amended claim 1 narrows the language of the claims from "comprising" to "consisting of" and further defines the definition of the monomer of the electrostrictive polymer. As such, the terpolymer of amended claim 1 and dependant claims 2 and 6 is neither taught nor suggested by the Nakamura reference. As a result, the rejections of the Office Action are resolved for claims 1 and dependant claims 2 and 6.

In regard to claim 8 and dependant claims 9 and 12, the language of claim 8 has been amended to reflect the conclusions discussed in the interview of September 7, 2005. More specifically, amended claim 8 further defines the definition of

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the monomer of the electrostrictive polymer. As such, the method of amended claim 8 and dependant claims 9 and 12 is neither taught nor suggested by the Nakamura reference. As a result, the rejections of the Office Action are resolved for claims 8 and dependant claims 9 and 12.

To supplement the remarks for claims 1-3, 6, 8-9 and 12 and to further explain the position of the Applicant during the interview of September 7, 2005; it is respectfully requested that the discussion as follows be considered:

In regard to Nakamura et al. (U.S. Patent 4,543,293), the reference is for a piezoelectric polymer. The polymers covered in the present application are not piezoelectric - they are electrostrictive. High strain, electrostrictive polymers based upon PVDF-TrFE were not discovered until the late 1990s. The date of the Nakamura reference is 1983. Thus, the Nakamura reference is not relevant to the present application in that the cited reference is not concerned with high strain electrostrictive fluoropolymers and that such materials would not even be discovered until fifteen years after the issue date of the Nakamura reference.

It is also noted that the polymer discussed in the Nakamura reference is a terpolymer of VDF, TrFE, and VF (vinyl fluoride). The terpolymers discussed in the present application are terpolymers of VDF, TrFE, and CFE (chlorofluoroethylene). These

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are two completely different materials. The Nakamura reference discusses replacing VF with tetrafluoroethylene, hexafluoropropylene and chlorotrifluoroethylene, but never discusses the use of CFE.

The Nakamura reference also tries to make a non-brittle, piezoelectric polymer with a high coupling constant. The polymers of the present application are non-brittle, but are electrostrictive and exhibit much higher strains and coupling constants. The polymers of the cited reference, being piezoelectric, need to be heat-treated and poled prior to use. The polymers of the present application, being electrostrictive, do not need such treatments in order to be electroactive.

In the Office Action, claims 4-5, 7, 10-11 and 13 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Nakamura et al. in view of Honn et al. In response, claims 4, 10 and 11 have been cancelled without prejudice or disclaimer and claims 1, 5, 7, and 13 have been amended by this response. More specifically and in accordance with the interview of September 7, 2005 and the respective interview summary, amended claim 1 (upon which claim 5 depends) narrows the language of the claims from "comprising" to "consisting of" and further defines the definition of the monomer of the electrostrictive polymer. As such, the terpolymer of amended claim 1 and dependant claim 5

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is neither taught nor suggested by the Honn reference. As a result, it would not be obvious to one skilled in the art to combine the Honn and Nakamura reference to produce the terpolymer of amended claim 1 and dependant claim 5. Therefore, the rejections of the Office Action are resolved for claim 5.

In regard to claim 7, the language of the claim has been amended to "consisting of" to "comprising" to remove the open language defining the electrostrictive polymer. As such, the terpolymer of amended claim 7 is neither taught nor suggested by the Honn reference. As a result, it would not be obvious to one skilled in the art to combine the Honn and Nakamura reference to produce the terpolymer of amended claim 7. Therefore, the rejections of the Office Action is resolved for claim 7.

In regard to claim 13, the language of the claim has been amended to "consisting of" to "comprising" to remove the open language defining the method of synthesizing an electrostrictive polymer. As such, the method of amended claim 13 is neither taught nor suggested by the Honn reference nor would the method be obvious in regard to the cited reference. As a result, the rejections of the Office Action are resolved for claim 13.

To supplement the remarks for claims 4-5, 7, 10-11 and 13 further explain the position of the Applicant during the interview of September 7, 2005; it is respectfully requested that the discussion above for the Honn and Nakamura references

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be incorporated herein to resolve the 35 U.S.C. § 103(a) rejection. It is further requested that discussion below be entered in regard to the Scheinbeim reference as well as the relation to the Honn and Nakamura references:

In regard to Scheinbeim et al. (U.S. patent 4,863,648), this is another reference that is concerned with making piezoelectric polymers. The reference issued in 1989 and thus predates the discovery of high-strain electrostrictive fluoropolymers by about eight years. In so far as the reference addresses piezoelectric polymers; it is irrelevant to the present application.

The Scheinbeim reference only discusses copolymers, not terpolymers, of vinylidene fluoride. Thus, the materials covered are copolymers of VDF with vinyl fluoride, trifluoroethylene, tetrafluoroethylene, and vinyl chloride. The terpolymers of the present application are not mentioned nor discussed. As a result, the Scheinbeim reference has minimal relation with the present application.

Generally, the present application discloses what polymer structures (VDF-TrFE-CFE or a VDF-TrFE-X terpolymer in which "X" favors gauche-type conformations in the polymer chains). The structures desirable for piezoelectric polymer are not necessarily the same as for a large-strain electrostrictor. None of the Honn, Nakamura and Scheinbeim references were trying

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to make a large-strain, electrostrictive polymer, and the polymers described would probably not work (Honn et al. is an unfocused type disclosure of a variety of different terpolymers, one of which is similar to the polymer of the present application (VDF-TrFE-CFE, but only the 1,1-CFE type. The ratios of VDF to TrFE to CFE that Honn reference suggests are not appropriate for high strain electrostriction in the polymer).

The Honn reference tries to make a crosslinked elastomer. There was no idea at the time that any of the polymers discussed exhibited electrostrictive properties. The discovery of high-strain electrostrictive polymers are not obvious from anything provided in the Honn, Nakamura, or Scheinbeim references. None of these references mentions high-strain electrostriction as being a property of the polymers that they discuss. High strain electrostriction was not even discovered in this family of fluoropolymers until the late 1990s - much later than the date of the most recent Scheinbeim of the three references.

The chemical and physical structures of a polymer that exhibits high-strain electrostriction is very different from those of a polymer that exhibits piezoelectricity. By itself, VDF-TrFE is not a high-strain electrostrictive polymer (it can be a piezoelectric polymer if processed correctly). The addition of the third monomer is what makes the VDF-TrFE a high-

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strain electrostrictor. The key criterion for the selection of the third monomer is that it must favor gauche-type conformations in the polymer backbone. This is not an obvious property to look for, nor is it something that was anticipated. Prior to this discovery, VDF-TrFE could be turned into a high-strain electrostrictive polymer only by means of high energy electron bombardment. The present application discloses making VDF-TrFE a high strain electrostrictor without the need for radiation. Chemistry alone can accomplish this by making VDF-TrFE a terpolymer by picking and using the proper third monomer. Not all possible third monomers favor gauche-type conformations in the polymer backbone (and it is not obvious to one skilled in the art which ones do and which ones do not and the existing monomers were found after molecular modeling). In addition to the gauche-type conformation, the halogen atom side groups on the third polymer must be of a size sufficient to increase the spacing between the adjacent polymer chains without inhibiting the formation of polymer crystallites.

The Honn reference discusses a wide variety of halogenated, unsaturated polymer building blocks, three of which could be assembled to make VDF-TrFE-CFE. The reasons for doing this, however, are very different from those in the present application. This can be seen by the fact that the Honn reference only discusses one of the two isomers of CFE but do

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not mention the 1,2 isomer. The reason for that is that the Honn reference wants some carbons to be $-CH_2-$ groups. That is possible with the 1,1 isomer of CFE, but not with the 1,2 isomer of CFE. Thus, the 1,2 isomer does not "work" for the Honn reference, but it does for the disclosure of the present application. Also, the Honn reference does not discuss the chain conformations present in any of the polymers listed. Apparently, polymer chain configuration is not important for the end-use of the Honn reference, but it is critical for the end use of the present application. Only some monomers favor the gauche-type conformations needed to make the high strain electrostrictor. In addition, only a relatively small amount of the third monomer (CFE) is added to VDF-TrFE to make the material a high strain electrostrictor. If too much of the third monomer is added, the properties deteriorate. The present application discloses the preferred amount of CFE to be added. The claim in the Honn reference that "any ratio" of VDF, TrFE, and CFE can be added together as long as "at least 10% of the polymer is comprised of $-CH_2-$ groups" would clearly not work if the goal was to make a high strain electrostrictor. Since VDF contains one CF_2 - and one $-CH_2-$ group per monomer unit, the Honn reference would allow 10% VDF and 90% TrFE (0% CFE) as a possible polymer. That does not make a high strain

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electrostrictor. Other possible combinations, such as 90% CFE, 5% VDF, and 5% TrFE, etc., would be equally poor.

There is no evidence that the Nakamura reference teaches or suggests synthesizing high strain electrostrictive polymers. The reference clearly tries to make piezoelectric polymers. Not all combinations of possible fluorinated/chlorinated monomers result in a usable, electroactive polymer. The Nakamura reference never mentions the specific polymers disclosed in the present application (VDF-TrFE-CFE). It is not clear that such a polymer would be of interest to the purposes of the Nakamura reference (the piezoproperties are likely to be inferior to plain old VDF-TrFE).

The present application teaches how to make high-strain electrostrictive polymers. The structures of some of the polymers that work may be referenced by others in the past for very different reasons and these earlier references may not have the ratios of the various components of the terpolymers correct for high-strain electrostriction. It would not be obvious to one skilled in the art nor would it follow from any cited reference what terpolymers work with regard to high strain electrostriction.

In addition to clarification provided by the amended claims and in accordance with the interview of September 7, 2005, the

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title of the invention has been amended to recite an
"Electrostrictive Polymer" rather than a "Piezo-Polymer".

In view of the Remarks above, the Applicants respectfully
request reconsideration and allowance of the application.

The Examiner is invited to telephone Michael P. Stanley,
Attorney for Applicants, at 401-832-6393 if, in the opinion of
the Examiner, such a telephone call would serve to expedite the
prosecution of the subject patent application.

Respectfully submitted,
THOMAS RAMOTOWSKI ET AL

13 October 2005



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